FORM PTO-1390 (REV 5-93) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE ATTORNEY'S DOCKET NUMBER

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

09/018193		
INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/01882	14 June 2000	14 June 1999

TITLE OF INVENTION: ELECTOSTATIC CORRECTOR FOR ELIMINATING THE CHROMATIC ABERRATION OF PARTICLE LENSES

APPLICANT(S) FOR DO/EO/US: ROSE, Harald; UHLEMANN, Stephan; WEISSBACKER, Christoph

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1)
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☒ are transmitted herewith (required only if not transmitted by the International Bureau)
   b. ☒ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☒ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: Int'l Preliminary Examination Report w/Article 19 Amds.

"Express Mail" mailing label number ET 670106852 US
Date of Deposit November 30, 2001

I hereby certify that this paper is being deposited with the U.S. Postal Service "Express Mail-Post Office to Addressee" service under 37 C.F.R. 1.10 on the date indicated above and is addressed to: Hon. Commissioner of Patents and Trademarks, Washington, D. C. 20231.

Edwin D. Schindler

Edwin D. Schindler, Reg. No. 31,459

November 30, 2001

Date

10/018193

17. [X] The following fees are submitted:	CALCULATIONS PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): $890.00 Search Report has been prepared by the EPO or JPO..... ~~$840.00~~	JC13 Rec'd PCT/PTO 30 NOV 2001
International preliminary examination fee paid to USPTO (37 CFR 1.482) **$640.00**	
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)).. **$710.00**	
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37CFR 1.445(a)(2)) paid to USPTO..... **$950.00**	
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4)..... **$90.00**	
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ -0-

Claims	Number Filed	Number Extra	Rate	
Total 7 Claims	7 -20 =	-0-	X $22.00	$ -0-
Independent Claims	1 -3 =	-0-	X $74.00	$ -0-
Multiple dependent claims(s) (if applicable)			+ $230.00	$ -0-
TOTAL OF ABOVE CALCULATIONS =				$ 890.00
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$ -0-
SUBTOTAL =				$ 890.00
Processing fee of **$130.00** for furnishing the English translation later the [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$ -0-
TOTAL NATIONAL FEE =				$ 890.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ -0-
TOTAL FEES ENCLOSED =				$ 890.00
			Amount to be: refunded	$
			charged	$

a. [X] A check in the amount of $ **890.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 19-0450. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Edwin D. Schindler
Five Hirsch Avenue
P. O. Box 966
Coram, New York 11727-0966

SIGNATURE

Edwin D. Schindler

NAME

31,459

REGISTRATION NUMBER

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANTS: HARALD ROSE ET AL. ART UNIT:

SERIAL NO.: 09/ EXAMINER:

FILED:

P.C.T. APPLICATION NO.: PCT/DE00/01882

P.C.T. INTERNATIONAL FILING DATE: JUNE 14, 2000

PRIORITY CLAIMED: JUNE 14, 1999

TITLE: ELECTROSTATIC CORRECTOR FOR ELIMINATING THE CHROMATIC ABERRATION OF PARTICLE LENSES

PRELIMINARY AMENDMENT

Hon. Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D. C. 20231

Dear Sir:

Prior to an examination on the merits of the above-identified patent application, please amend the English translation of the above-identified application as follows:

IN THE ABSTRACT OF THE DISCLOSURE

Please use the accompanying Abstract of the Disclosure,

"Express Mail" mailing label number ET 670106852 US
Date of Deposit November 30, 2001

I hereby certify that this paper is being deposited with the U.S. Postal Service "Express Mail - Post Office to Addressee" service under 37 C.F.R. §1.10 on the date indicated above and is addressed to: Hon. Commissioner for Patents, United States Patent and Trademark Office, Washington, D. C. 20231.

Edwin D. Schindler, Reg. No. 31,459

November 30, 2001
Date

which is contained on a separate sheet of paper, as required by 37 C.F.R. §1.72(b), as the Abstract for the instant patent application.

IN THE SPECIFICATION

Please amend the Specification, which consists of: (1) amended Pages 1 - 3, as filed September 4, 2001, before the IPEA/EP during Chapter II of the P.C.T. international phase; and, (2) of Pages 4 - 12, as being the literal English translation of the P.C.T. application filed on June 14, 2000:

Page 1, between lines 2-3 (immediately beneath the Title of the Invention), insert the following headings:

--BACKGROUND OF THE INVENTION--; and,

--Technical Field of the Invention--.

Page 1, lines 3-6, rewrite this paragraph to now read as follows:

--The invention relates to an electrostatic corrector for eliminating the chromatic aberration of particle lenses, with a straight optical axis and an electrostatic quadrupole for allocating to an objective lens.--

Page 1, between lines 6-7, insert the following heading:

--Description of the Prior Art--

Page 2, between lines 23-24, insert the following heading:

--SUMMARY OF THE INVENTION--.

Page 4, lines 1-7 (amendment to correct deletion of last three lines of literal English translation, which were erroneously deleted upon entry of Article 19 Amendments before the EP/IPEA on September 4, 2001), rewrite this paragraph to now read as follows:

--The proposed electrostatic corrector, in its preferred construction, comprises four elements arranged one behind the other in the direction of the straight optical axis, namely - in the direction of the optical axis starting from the objective - first of a quadrupole and two corrector pieces arranged one behind the other, and finally - at the output end - of a further quadrupole. The quadrupole fields of the two corrector pieces are rotated with respect to one another about an angle of 90o about the optical axis.--

Page 10, between lines 28-29, insert the following:

--BRIEF DESCRIPTION OF THE DRAWING FIGURE--

--The single drawing figure schematically illustrates the preferred construction and function of the electrostatic corrector of the present invention.--

--DETAILED DESCRIPTION OF THE DRAWING FIGURE AND PREFERRED EMBODIMENTS--.

IN THE CLAIMS

Please cancel Claims 1-7, as filed during the P.C.T. international phase and as filed on September 4, 2001, before the IPEA/EP (i.e., cancel all prior claims), and substitute

the following claims therefor:

--8. An electrostatic corrector for eliminating chromatic aberration of particle lenses having a straight optical axis and an electrostatic quadrupole for allocation to an objective lens, said electrostatic corrector comprising:

two corrector pieces positioned behind said electrostatic quadrupole and along said straight optical axis in a direction of radiation, said two corrector pieces having quadrupole fields rotatable 90° about said straight optical axis in relation to one another, with rotation able to occur so that a first astigmatic intermediate image of a first section lies in a first corrector piece of said two corrector pieces and a second astigmatic intermediate image perpendicular thereto, of a second section, lies in a second corrector piece of said two corrector pieces, with an additional electrostatic quadrupole being located on an output side, with each of said two corrector pieces having three electrical quadrupole fields with said electrostatic quadrupoles being overlaid with a circular lens field.

9. The electrostatic corrector for eliminating chromatic aberration of particle lenses according to Claim 8, wherein said two corrector pieces have symmetrical constructions.

10. The electrostatic corrector for eliminating chromatic aberration of particle lenses according to Claim 8,

wherein said two corrector pieces have center planes and symmetrical extensions of said quadrupole fields with respect to said center planes.

11. The electrostatic corrector for eliminating chromatic aberration of particle lenses according to Claim 8, wherein said quadrupole fields of said two corrector pieces are overlaid by at least one quadrupole field.

12. The electrostatic corrector for eliminating chromatic aberration of particle lenses according to Claim 11, further comprising octopole fields arranged in a region of said first astigmatic intermediate image and said second astigmatic intermediate region.

13. The electrostatic corrector for eliminating chromatic aberration of particle lenses according to Claim 11, wherein a single multipole element generates both a quadrupole and an octopole filed.

14. The electrostatic corrector for eliminating chromatic aberration of particle lenses according to Claim 11, further comprising a third corrector piece connected downstream in a direction of said straight optical axis, said third corrector piece having a spatial arrangement and intensity of its circular lens fields and quadrupole fields so as to be a mirror symmetrical relative to a center point of said second corrector piece.--

REMARKS

Prior to an examination on the merits of the above-identified patent application, please enter the foregoing amendments.

Claims 8-14 are now pending in the above-identified patent application, as presented by the instant Preliminary Amendment. Claim 8 is the single claim presented in independent form.

The present application represents the U.S. National Phase of P.C.T. Application No. PCT/DE00/01882, filed June 14, 2000, and claiming foreign priority on the basis of a corresponding Federal Republic of Germany patent application, filed June 14, 1999.

The claims being entered via the present Preliminary Amendment are intended to substitute for Claims 1-7 of the P.C.T. international application, as amend on September 4, 2001. An English translation of the P.C.T. international application and of the amended disclosure and claims is being concurrently filed.

The current Specification is the English translation of amended Pages 1 - 3 (as amended on September 4, 2001); and, the English translation of Pages 4 - 12 of the originally-filed P.C.T. application; all as amended by this Preliminary Amendment.

New Claims 8-14, which have been drafted in conformance with U.S. claim practice. Various formal amendments have also been entered to the Specification, and an Abstract for the application, on a separate sheet of paper, is enclosed.

A "marked-up" version of the amendments to the Specification is enclosed.

The application is now in condition for a full examination on the merits.

Accordingly, an early examination on the merits and allowance are, therefore, respectfully requested and earnestly solicited.

Respectfully submitted,

HARALD ROSE ET AL.

By _____
Edwin D. Schindler
Attorney for Applicants
Reg. No. 31,459

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P. O. Box 966
Coram, New York 11727-0966

(631)474-5373

November 30, 2001

ABSTRACT OF THE DISCLOSURE

An electrostatic corrector for eliminating the chromatic aberration of particle lenses, includes a corrector having a straight optical axis and an electrostatic quadrupole for allocating to the objective lens. Two corrector pieces are positioned behind the quadrupole, along the optical axis in the direction of radiation. Each corrector piece has three electrical quadrupole fields with an overlying circular lens field. The quadrupole fields, however, are rotated 90° about the optical axis in relation to each other. This arrangement is adjusted so that the astigmatic first image of one sectional view lies in one corrector piece and the astigmatic first image perpendicular thereto, of the other sectional view, lies in the other corrector piece, with another electrostatic quadrupole being located on the output side.

VERSION OF AMENDMENTS WITH MARKINGS TO SHOW CHANGES MADE
(Dated November 30, 2001)

IN THE SPECIFICATION

Please amend the Specification, which consists of: (1) amended Pages 1 - 3, as filed September 4, 2001, before the IPEA/EP during Chapter II of the P.C.T. international phase; and, (2) of Pages 4 - 12, as being the literal English translation of the P.C.T. application filed on June 14, 2000:

Page 1, between lines 2-3 (immediately beneath the Title of the Invention), insert the following headings:

--BACKGROUND OF THE INVENTION--; and,

--Technical Field of the Invention--.

Page 1, lines 3-6, rewrite this paragraph to now read as follows:

--The invention relates to an electrostatic corrector for eliminating the chromatic aberration of particle lenses, with a straight optical axis [according to the generic part of Claim 1.] and an electrostatic quadrupole for allocating to an objective lens.--

Page 1, between lines 6-7, insert the following heading:

--Description of the Prior Art--

Page 2, between lines 23-24, insert the following heading:

--SUMMARY OF THE INVENTION--.

Page 4, lines 1-7 (amendment to correct deletion of last three lines of literal English translation, which were erroneously deleted upon entry of Article 19 Amendments before the EP/IPEA on September 4, 2001), rewrite this paragraph to now read as follows:

--The proposed electrostatic corrector, in its preferred construction, comprises four elements arranged one behind the other in the direction of the straight optical axis, namely - in the direction of the optical axis starting from the objective - first of a quadrupole and two corrector pieces arranged one behind the other, and finally - at the output end - of a further quadrupole. The quadrupole fields of the two corrector pieces are rotated with respect to one another about an angle of 90° about the optical axis.--

Page 10, between lines 28-29, insert the following:

--BRIEF DESCRIPTION OF THE DRAWING FIGURE--

--The single drawing figure schematically illustrates the preferred construction and function of the electrostatic corrector of the present invention.--

--DETAILED DESCRIPTION OF THE DRAWING FIGURE AND PREFERRED EMBODIMENTS--.

MARKED-UP AMENDMENTS-2

1/prt

Electrostatic Corrector for Eliminating the Chromatic Aberration of Particle Lenses

The invention relates to an electrostatic corrector for eliminating the chromatic aberration of particle lenses, with a straight optical axis and an electrostatic quadrupole for allocating to the objective lens.

According to the Scherzer theorem (O. Scherzer, Zeitschrift für Physik 101, (1936) 593), it is known that in optical reproduction systems for charged particles, which is understood to mean principally electrons and ions, with the use of static, space-charge-free and rotationally symmetrical fields, the chromatic aberration (colour deviations) and spherical aberration (focussing deviations) do not necessarily disappear. Since these errors limit the capability of the reproductive optical systems and in particular the resolution capability, there has been no lack of attempts to eliminate these image errors. Most success is promised by the departure from rotationally symmetrical lenses, that is to say the use of non-circular lenses in the form of multipoles, in particular quadrupoles, octopoles and the like. By means of a corrector of this kind made up from electrical and magnetic multipoles, the two managing directors of the applicant have succeeded in completely correcting the spherical and chromatic aberration in a low-voltage scanning electron microscope (J.Zach, M. Haider Nucl. Instr. method A363 (1995) 316), wherein it was possible to

demonstrate a resolution capability of 2 nm at an electron energy of 1 kV.

The disadvantages of the electromagnetic multipole correctors can be seen in the fact that, because of the remanence, the magnetic fields do not allow fast, precise and reproducible adjustment of the magnetic fields. A demagnetisation also requires removal of the coil cores, which represents considerable effort. Over a relatively long period, a relatively large drift of the magnetic fields occurs. Finally, the strong magnetic fields necessary in ion-optical devices, such as, for example, lithography, because of the large ion masses, can only be implemented with difficulty because of the dependency of focusing on the mass. Correctors for eliminating the chromatic aberration with purely electrical fields in both sections are not known.

On this basis, the object of the invention is to provide a corrector for eliminating the chromatic aberration of particle lenses, which is constructed entirely from electrical fields, that is to say without the use of magnetic fields.

This object is attained according to the invention in that two corrector pieces are arranged along the optical axis upstream of the quadrupole in the beam direction, each corrector piece has two electrical quadrupole fields with overlaid circular lens field, whose quadrupole fields, however, are rotated relative to one another through an angle of 90° about the optical axis, and the adjustment is carried out

such that the astigmatic intermediate image of one section lies in one corrector piece and the astigmatic intermediate image, which is perpendicular thereto, of the other section lies in the other corrector piece, and finally a further electrostatic quadrupole is arranged at the output side.

The term chromatic aberration in the sense of the invention, in exact terminology, means the first order, first degree axial chromatic aberration. Herein, the word "axial" describes the fact that this chromatic aberration is only determined by the fundamental paths emerging from the optical axis in the object point, that is to say the fundamental solutions to the Gaussian optics. The chromatic aberration is thus independent of the extra-axial paths. The order describes the power to which the initial gradient of the fundamental path enters into the chromatic aberration; the first order case there is a linear dependency. The term "first degree" describes the fact that the chromatic aberration has a linear dependency on the relative velocity deviation of the mean velocity of the particles. In the case of monochromatic particles - i.e. particles of equal velocity and therefore also constant wavelength - the relative deviations thus become zero. In this case there is no chromatic aberration. In the language of optics, the chromatic aberration is often also termed "colour deviation".

The proposed electrostatic corrector, in its principle construction, consists of four elements arranged one behind the other in the direction of the

straight optical axis, namely - in the direction of the optical axis starting from the objective - first of a quadrupole and two corrector pieces arranged one behind the other, and finally - at the output end - of a further quadrupole. The quadrupole fields of the two corrector pieces are rotated with respect to one another about an angle of 90° about the optical axis.

The beam path in the corrector travels as follows: the axial beam path starting from the centre of the object is first deflected by the objective lens and, after entry into the corrector, is first deflected by the electrical quadrupole in different manners in the two sections (X and Y section). The particle bundle is thereby focused in one section (e.g., in the X section) and caused to diverge in the other section (Y section), so that an astigmatic intermediate image is produced, which passes through the optical axis and is expediently positioned in the centre of the first corrector piece. This corrector piece therefore does not significantly affect the path trajectory in the section in which the intermediate image lies (X section), because the axial path passes close to the optical axis and intersects it, wherein positive chromatic aberrations do occur, but because of the low distance from the axis they are only very small. In the section perpendicular thereto (Y section), on the other hand, the path trajectory, due to the quadrupole fields of the corrector piece, experiences a considerable influence and negative contribution to the chromatic aberration. There is thus an influencing of the chromatic aberration of one

section in the first corrector piece and, in an analogous manner, of that of the second section in the second corrector piece. In dependence on the set potentials, an influencing of the chromatic aberration and in the ideal case a compensation of the chromatic aberration of the objective lens follow, so that the entire optical system formed of the objective lens and corrector has reproduction properties free of chromatic aberrations. The last quadrupole serves to re-combine the ray path to rotational symmetry again.

The generation of the astigmatic intermediate image within the corrector piece, i.e. the zero crossing of the corresponding paraxial path can be achieved by appropriate choice of the strength of the electrical quadrupole present at the input of the corrector. Variation of the potential of the electrical quadrupole fields of the corrector piece (circular lens component as well as quadrupole field intensity) with respect to one another, that is to say the opposing field between the quadrupole fields, results in the influencing and setting of the chromatic aberration.

The decisive advantages of the electrostatic corrector consist in a rapid and precise adjustment and setting of the fields, a problem-free handling with reproducible conditions even over a relatively long time period and also in the possible use in ion-optical equipment.

Particularly preferred embodiments are those in which a symmetrical construction and/or symmetrical course within a corrector piece with respect to its centre plane and/or a symmetrical construction and/or symmetrical course of the fields of the two corrector pieces, with respect to the centre plane between them is provided. Because of the symmetrical/anti-symmetrical course of the paraxial paths within the corrector pieces, numerous error integrals are cancelled out, or are at least made clear in an analytical manner and can be resolved without problem, which substantially contributes to the transparency and understanding of the behaviour of the corrector in different situations and settings. The symmetry with respect to the centre plane of a corrector piece both in construction and in the setting of the electrical fields has the consequence that the zero crossing of the corresponding paraxial path comes to lie exactly in the centre plane. In addition, the two outer quadrupole fields of the same corrector piece are then identical.

Because of the construction and symmetry of the fields of the two corrector pieces, with maintenance of the relative rotation between them of 90°, an identical path trajectory is obtained in both sections, i.e. the correction of one section made in the first corrector piece takes place in the other section in the second corrector piece.

The resulting advantages are simple analytical resolvability and, because of the clarity, a resulting understanding of the behaviour of the

corrector. Not only the adjustment is simplified, but also the handling in general; the possibility of setting fewer potentials also contributes to simplification.

On the setting of the corrector:
In principle it is possible, by influencing the chromatic aberration, to achieve any optional setting of the chromatic aberration of the overall system consisting of an objective lens and corrector. Often the declared aim is to make the overall aberration of the entire system zero, that is to say by means of the corrector to generate a negative chromatic aberration component, which compensates the further positive chromatic aberration generated from the objective lens and the individual corrector elements. In the above-described symmetrical conditions, only two parameters are available for setting the corrector piece, namely the ratio of the outer and centre circular lens field and the intensity of the quadrupole field.

The elimination of the chromatic aberration takes place in an iterative process, which in the case of the above-described symmetrical construction also becomes particularly clear, and is described below: With a constant ratio of the two circular lens potentials of the corrector piece, the quadrupole intensity is varied, and thereby the chromatic aberration coefficient is measured. As soon as the chromatic aberration reaches its minimum value, the ratio of the circular lens field is also varied with the aim of further minimising the chromatic

aberration. By multiple interative steps in the above-described manner, the chromatic aberration can then be completely eliminated. Mathematical considerations show that a complete correction of the chromatic aberration will only be possible for particular regions of the circular lens potentials of the corrector piece and of the quadrupole field intensities.

As mentioned at the outset, the capability of electron-optical imaging systems is limited by chromatic aberration and spherical aberration. The object of the above-described corrector consists in eliminating the first order, first degree axial chromatic aberration. In numerous applications, it is sought to additionally eliminate the spherical aberration, more specifically the third-order axial spherical aberration. To this end, octopole fields, that is to say fourfold fields, overlay the quadrupole fields. In the symmetrical construction described as a special embodiment, the octopole field overlays the centre quadrupole field of the corrector piece. Through the choice and setting of the intensity of the quadrupole field, a setting and, if appropriate, compensation of the third-order axial spherical aberration is completely decoupled from the setting of the quadrupole fields serving to eliminate the chromatic aberration.

For the constructional implementation, it is possible in a single multipole element to generate quadrupole as well as octopole fields.

In a preferred further developmentf, it is proposed to arrange a further, third corrector piece in the direction of the optical axis upstream of the existing corrector consisting of two corrector pieces. Both as regards the spatial arrangement as well as the intensity of the quadrupole and circular lens fields, a mirror-symmetrical arrangement with respect to the centre plane of the second corrector piece and thereby with respect to the plane extending through the centre of the corrector consisting of three corrector pieces. As a result, a third corrector piece is obtained, which is of mirror-symmetrical construction to the first corrector piece. For the two axial elementary paths, that is to say elementary paths proceeding from the optical axis in the object point, the path proceeding in the alpha section has point symmetry with respect to centre of the corrector and the β-path proceeding perpendicular thereto has mirror symmetry with respect to the centre of the corrector. The extra-axial paths proceeding outside the optical axis are, as regards the gamma section, mirror-symmetrical with respect to the centre of the corrector, and the delta path extending in the plane perpendicular thereto proceeds point-symmetrically with respect to the centre of the corrector. In the first and third corrector piece, specifically in the astigmatic intermediate image of the β path, a correction of the chromatic aberration in the xz section takes place. In the middle (second) corrector piece, the correction in the yz section follows in the astigmatic intermediate image of the alpha path. In general, the chromatic aberrations are

different in the two sections. The optimum setting of the corrector is then obtained when the excitation of the corrector pieces and the geometry, in particular the distance between the front quadrupole and first corrector piece and between the corrector pieces, is chosen such that optimum setting of the corrector is provided. By means of this change of the geometry, the incidence into the second corrector piece can be optimised. Although the path incidence into the first and third corrector pieces is then less favourable as regards the chromatic aberration correction in the xz section, this disadvantage can be eliminated by the fact that the correction in this section is distributed between two corrector pieces, and thereby a compensation becomes possible. Because of the symmetry of the paths and the fields with respect to the centre of the corrector, and thereby with respect to the centre of second corrector piece, all extra-axial with a linear axial distance can be eliminated. The possibility is obtained of transmitting an extended image field, with the consequence that this corrector is also suitable for use beyond the scanning electron microscope. A contribution to this is also the elimination of the image aberration of the coma. A further advantage of this arrangement is the reduction of the combination aberration and here in particular minimisation of the third and fifth order axial image aberrations.

Further details, feature and advantages of the invention can be taken from the following descriptive part, wherein the construction and function of the

electrostatic corrector proposed according to the invention can be obtained with reference to the drawing. The paraxial paths α,β proceed from the object (1) and are deflected by the objective lens (2) which is subject to chromatic aberration. The corrector (3) consists in its basic construction of a quadrupole directed towards the objective lens (4), a first corrector piece (5) adjoining in the direction of the ray path (5) and a further corrector piece (6) arranged at a distance therefrom. As can be seen from the drawing, the quadrupole (4) effects a splitting in the axial paths α, β, which proceed in different sections, namely firstly in the direction of the optical axis (Z) and another section perpendicular thereto. The corrector piece (5) consists of three quadrupole fields (5a, 5b, 5c), which are symmetrical, i.e. the two outer quadrupole fields are equal in intensity and lie symmetrical to the centre quadrupole fields (5b). For production of a symmetrical ray path, a further quadrupole (7) is arranged at the output side.

The construction, symmetrical with respect to the centre plane (Z_M), of the corrector pieces (5, 6), which are only rotated relative to one another through 90° with respect to the optical axis (z), results in an equal path trajectory in the section plane rotated through 90°. One corrector piece (5) effects an influencing and elimination of the chromatic aberration in that sectional plane in which the α path proceeds. The other corrector piece (6) acts on the β path proceeding in the other section,

so that each of the corrector pieces (5, 6) effects the influencing or even the elimination of the chromatic aberration in one of the two sections. All quadrupole and circular lens fields are of electrostatic nature.

Not drawn is the fact that, by overlaying of octopole fields, principally in the region of the astigmatic intermediate images, a correction of the spherical aberration (3rd order axial focussing deviation) can be carried out. A considerable influencing of the efficiency of the particles of optical imaging systems can be achieved by elimination of the chromatic aberration and possibly also of the spherical aberration.

PATENT CLAIMS

1. Electrostatic corrector for eliminating the chromatic aberration of particle lenses, with a straight optical axis and an electrostatic quadrupole for allocating to the objective lens, **characterised in that**
- two corrector pieces are positioned behind the quadrupole, along the optical axis in the direction of radiation,
-. each corrector piece has three electrical quadrupole fields with an overlying circular lens field,
- the quadrupole fields, however, are rotated 90 degrees about the optical axis in relation to each other, and
- adjustment takes place in such a way that the astigmatic intermediate image of one section lies in one corrector piece and the astigmatic intermediate image perpendicular thereto, of the other section, lies in the other corrector piece, with another electrostatic quadrupole being located on the output side.

2. Corrector according to claim 1, **characterised by** a symmetrical construction of the corrector piece and/or a symmetrical extension of the fields of a corrector piece with respect to their centre planes.

3. Corrector according to claim 1 or 2, **characterised by** a symmetrical construction of the corrector

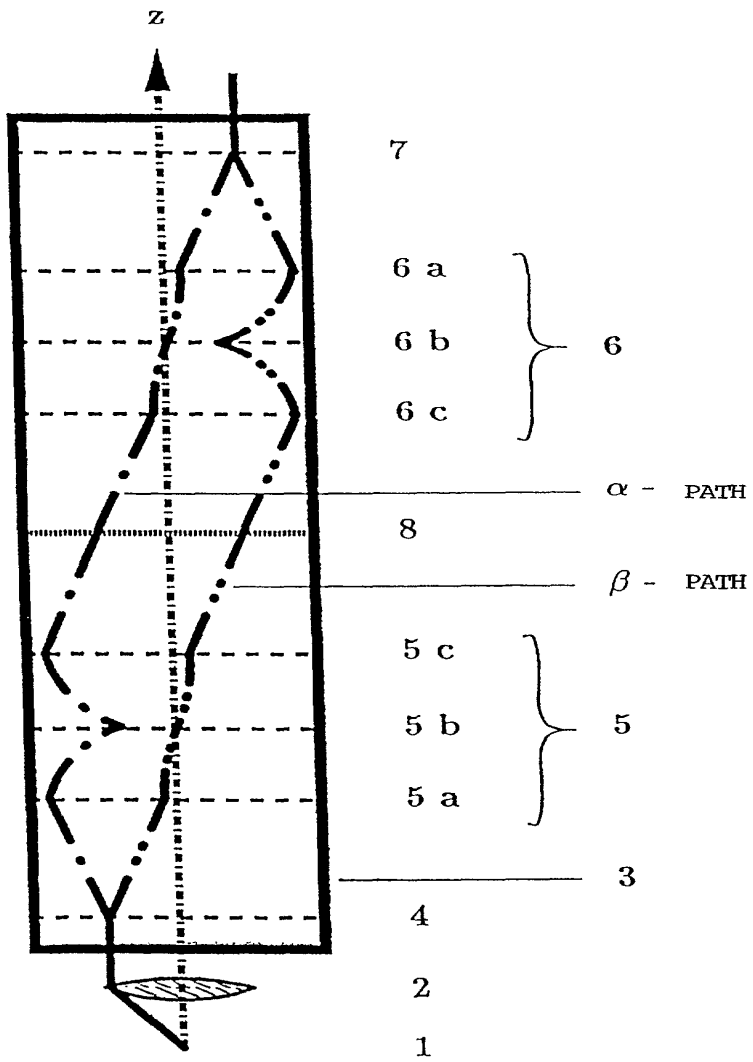
and/or a symmetrical extension of the fields with respect to the centre plane defined by the two corrector pieces.

4. Corrector according to claims 1 to 3, **characterised in that** the quadrupole fields of the corrector pieces are overlaid by at least one quadrupole field.

5. Corrector according to claim 4, **characterised in that** the octopole fields are arranged in the region of the respective astigmatic intermediate images.

6. Corrector according to claim 4 or 5, **characterised in that** one and the same multipole element generates both a quadrupole and an octopole field.

7. Corrector according to one of the preceding claims, **characterised in that** a further (third) corrector piece is connected downstream in the direction of the optical axis, the spatial arrangement and intensity of its circular lens fields and quadrupole fields being chosen so as to be mirror symmetrical with respect to the centre of the second corrector piece.


z
7
6 a
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1

Declaration and Power of Attorney For Patent Application
Erklärung Für Patentanmeldungen Mit Vollmacht
German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

Elektrostatischer Korrektor zur Beseitigung des Farbfehlers von Teilchenlinsen

deren Beschreibung

(zutreffendes ankreuzen)

☐ hier beigefügt ist.

☒ am 14.06.2000 unter der

Anmeldungsseriennummer PCT/DE 00/0182

eingereicht wurde und am _____

abgeändert wurde (falls tatsächlich abgeändert).

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Electrostatic Corrector for eleminating the chromatic abberation of particle lenses

the specification of which

(check one)

☐ is attached hereto.

☒ was filed on 14.06.2000 as

Application Serial No. PCT/DE 00/01882

and was amended on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign applications
Priorität beansprucht

(Number) (Nummer)	(Country) (Land)	(Day/Month/Year Filed) (Tag/Monat/Jahr eingereicht)	Priority Claimed Yes Ja	No Nein
19926927.0	Germany	14.06.1999	☒	☐
			☐	☐
			☐	☐

Ich beanspruche hiermit gemass Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 112 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1 56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.) (Anmeldeseriennummer)	(Filing Date) (Anmeldedatum)	(Status) (patentiert, anhangig, aufgegeben)	(Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklarung in Kenntnis dessen abgebe, dass wissentlich und vorsatzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsatzlich falsche Angaben die Gultigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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German Language Declaration

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Staatsangehörigkeit german	Citizenship german
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Voller Name des zweiten Miterfinders (falls zutreffend) Dr. Stephan Uhlemann	Full name of second joint inventor, if any
Unterschrift des Erfinders Datum X Stephan Uhlemann 29.1.02	Second Inventor's signature Date
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Staatsangehörigkeit german	Citizenship
Postanschrift ~~Rathausstraße 29~~ Bahnhofstr. 3	Post Office Address
D-~~69126~~ 69115 Heidelberg	

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors.)